Annual Project Summary

DEEP BOREHOLE TENSOR STRAIN MONITORING, SOUTHERN CALIFORNIA

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II

seismology, geodesy, borehole geophysics

Project Objectives and Approach

This project provides field observations critical to an understanding of fault processes associated with earthquakes along the San Andreas and Sierre Madre faults. Continuous high precision and high resolution borehole tensor strain data provide an essential complement to long baseline interferometry studies (limited to sampling intervals of weeks), GPS studies, and seismic characterisation of faults.

The project continues a program of maintenance and analysis of deep borehole tensor strain instrumentation initiated at Pinon Flat in late 1983, and a further deployment in the San Gabriel mountains region (Coldbrook) in 1996. These instruments consist of a three component plane strain module operating at strain sensitivity of 10^{-10} and support data logging systems. As deployed they provide data sampling at 30 minute intervals for transmission via satellite for permanent archive purposes. The instruments provided by this project are unique in the program in that they provide continuous tensor strain data of high quality and sensitivity not achievable by any other instrumentation. These data form a critical complement to GPS and geodetic studies in assessing strain rates and consequent earthquake risk, as well as investigating fault processes associated with earthquake preparation and postseismic relaxation. Archived long term baseline data are available from *http://www.cat.csiro.au/dem/msg/straincal/straincal.html*. Data are made available in near real time in the USGS Menlo Park computer system (***thecove:/home/mick/QUICKCHECK***). These data supplement long baseline survey data, and permit real time monitoring for short term strain phenomena.

The **immediate objectives** of the project are

- Maintenance of uphole system integrity at 2 Southern Californian sites, with repair or production of replacement uphole electronics if necessary.
- Manual preparation of raw instrument data for permanent archive.
- Analysis of continuous unique low frequency shear strain data (30 minute samples) and modelling studies based on the constraints of these data
- Near real time alert response to the earthquake studies community when necessary.

- Archive of processed data for access by the earthquake studies community, and provision of near-real time automatically processed data for inclusion in publically accessible web pages linked to the USGS web datasets.

The project is carried out in parallel with maintenance of five further sites (San Juan Bautista, along the Hayward fault and near Parkfield) in Northern California.

Investigations & Results

Long Term strain data

One of the three channels (gauge 2) in the Pinon Flat BTSM instrument suffered significant degradation in gain from 1999 onwards, due to component aging in the downhole preamp (after 20 years of continuous operation). The internal gain compensation system ran out of dynamic range in mid-2000. In December 2000 an uphole gain compensating circuit was installed on this channel. Normal operations have resumed, allowing the 18 year datset baseline to be continued. The gauge component data are shown in the lower traces of Figure 1, and calculated strain in the upper panel..

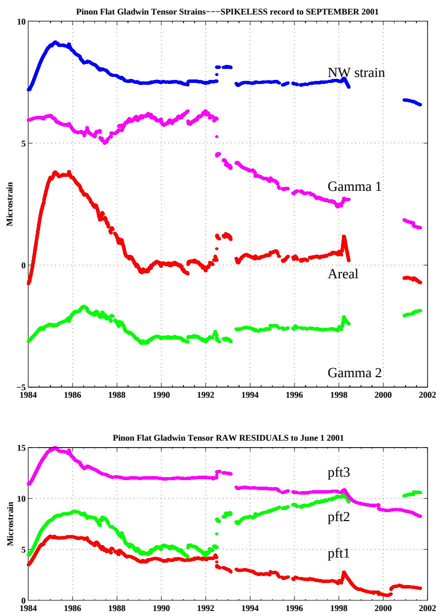

Figure 1. Pinon Flat tensor strainmeter data. Lower panel shows each raw component since installation in 1983. Component 2 experienced some downhole failure in 1998, and repairs to the uphole electronics to recover this component were effected in late 2000. Upper panel shows the resulting strain components.

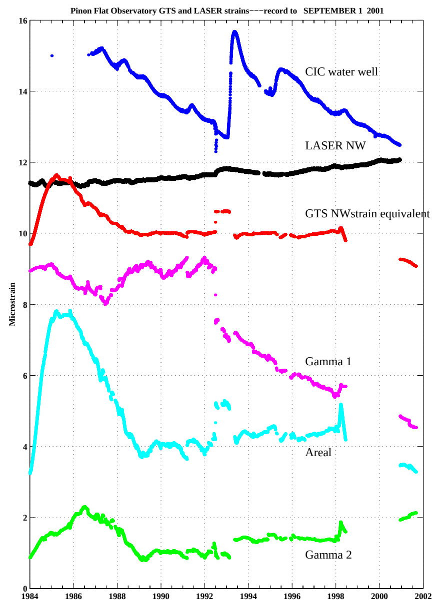

Figure 2 Data from Pinon Flat tensor strainmeter since installation in 1983. *Traces in order from top, show*: aquifer level in nearby water well; nearby laser strainmeter NW data, calculated NW strain from tensor strainmeter data, and three tensor strainmeter components gamma1, areal and gamma 2.

Shown in Figure 2 for comparison are aquifer level in water well CIC, and north-west laser strain data. The anomaly in strain in early 1998 is correlated with an anomalous change in aquifer level, and probably is caused by precipitation during that period. The large changes in 1992 were caused by the Landers earthquake.

Propagating event in San Gabriel.

The Coldrook site is situated in the San Gabriel mountains, and together with three USGS operated borehole dilatometers ***puba*** (20km NW), ***cnts*** (15 km SW) and ***bdts*** (15 km SE) forms a 4 instrument array in the region between the Sierre Madre and San Andreas faults. The Coldbrook instrument was installed in late 1996, and borehole recovery processes evident in the data in the form of exponential signals have been removed.

Anomalous strain changes were observed on all of the strainmeters in the Sierra Madre array sites in late October 2001 (see Figure 3 below). There was no precipitation recorded during this period. The tensor strainmeter (Coldbrook) indicates a changes of gradient of greater than 200 nanostrain per year predominantly in the gamma2 shear strain component. Strain offsets were observed at **puba** on 12 October, and at both **cnts** and **bdts** on 19 October, with smaller offsets on 25 October. The puba signal also indicates a change of strain gradient following the offset event. The correspondence of these strain changes across the array suggests a strain signal propagating from north (on the San Andreas fault) towards the south (Sierra Madre fault) at an approximate rate of 5 km per day.

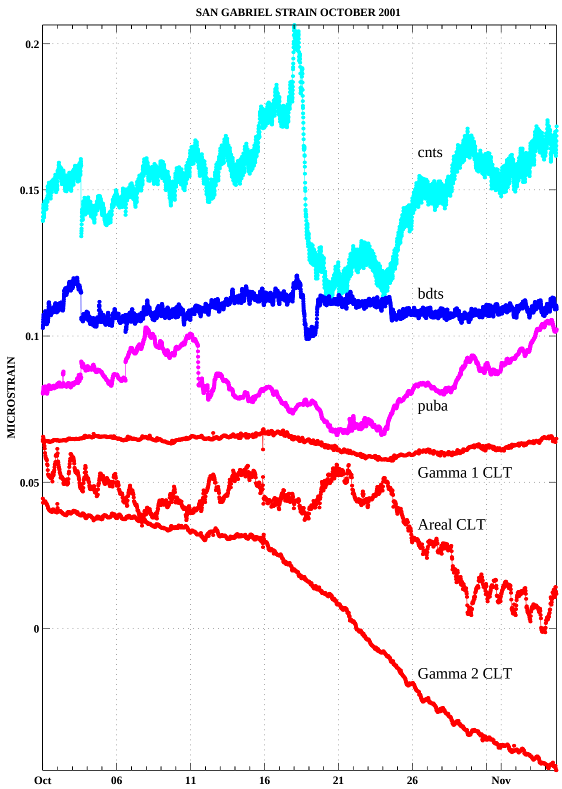

Figure 3. Initiation of strain gradient changes at **pub**, **clt** and **cnt** occurred during October 2001. Events occur at pub (12 October, clt (16 October, and cnts, bdts (19 October), and then again at each site on 25 October.. The temporal progression of the initial events may indicate a strain propagation at 5 km per day.

Note that results from the borehole tensor strainmeters situated at Parkfield and in northern California are detailed in the companion Northern California report.

Data Availability

Archived strain data from the Californian sites are stored in both raw component form, and as processed areal and shear strains. A regularly updated archive of data has been maintained in the USGS Menlo Park computer system since 1988. This data is stored in binary files with appended header information (USGS "*bottle*" format).

Home page for access to data plots from all borehole tensor strain instruments is *http://www.cat.csiro.au/dem/msg/straincal/straincal.html* ***This page also includes facilities for download of raw or processed data from our CSIRO archive.***

Automatically processed near-realtime data is available in *thecove:/home/mick/QUICKCHECK* for users with access to USGS plotting software "*xqp*", and via the USGS crustal deformation web pages in graphical form.

Scientists requiring other access to the archived data should contact Dr. R. Gwyther (+617 3327 4586, email: *ross.gwyther@csiro.au*) or Dr. M.T. Gladwin (+617 3327 4562, email *michael.gladwin@csiro.au*).

Publications

Publications 2000 - 2001

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Non-Technical Summary

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